agricultural research

U.S. DEPARTMENT OF AGRICULTURE JUNE 1978

agricultural research

June 1978/Vol. 26, No. 12

Tomorrow's Discoveries

OUR LONG JOURNEY into tomorrow will not be easy. As the world population increases, our supply of energy diminishes. The raw materials to produce food and fiber are finite.

Our plentiful harvests based mainly on modern agricultural techniques—generous and skillful use of chemicals, machines, irrigation, and conventional genetics—are beginning to level off. Crops and farm animals have begun to reach their natural productive limits.

If U.S. farmers are to continue feeding their fellow citizens, as well as producing an exportable surplus, they must exploit tomorrow's discoveries.

Science and technology offer the best hope. The well-being of the entire human race depends upon the outcome of various imaginative experiments aimed at overcoming present biological limits to food production.

On one hand, we must learn to manipulate nature to reach and go beyond the natural upper limits in crop production. On the other, we must not upset the delicate balance of our environment. Truly, a death-defying feat.

Photosynthesis seems to hold the key to making the earth more productive. During photosynthesis, the chlorophyll of leaves—powered by sunlight—turn carbon dioxide and water into the sugars that ultimately feed all life. The average leaf, however, captures and fixes a paltry 1 percent of incoming solar energy.

We must learn to make our plants more efficient. To do this, SEA scientists are studying all aspects of plant growth—genetics, plant physiology, pest management, and photosynthesis. A new microcomputer-controlled system (see p. 8) will permit scientists to test and study whole-plant responses to climate and environment.

Today's research in crop production is only a beginning. Combined with the potential for tomorrow's discoveries, however, this research can assure a safe journey into the future.—*M.M.M.*

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COVER: SEA researchers working in cooperation with Clemson University have a new method for evaluating plant responses to changes in soil and climate. Article begins on page 8 (0378X326-32A).

AGRICULTURAL RESEARCH is published monthly by the Science and Education Administration (SEA), U.S. Department of Agriculture, Washington, D.C. 20250. The Secretary of Agriculture has determined that the publication of this periodical is necessary in the transaction of the public business required by law of this Department. Use of funds for printing this periodical has been approved by the Director of the Office of Management and Budget through June 15, 1982. Yearly subscription rate is $6.50 in the United States and countries of the Postal Union, $8.15 elsewhere. Single copies are 55 cents domestic, 70 cents foreign. Send subscription orders to Superintendent of Documents, Government Printing Office, Washington, D.C. 20402. Information in this magazine is public property and may be reprinted without permission. Prints of photos are available to mass media; please order by photo number.

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Diabetes . . . A Means of Controlling Insects ?

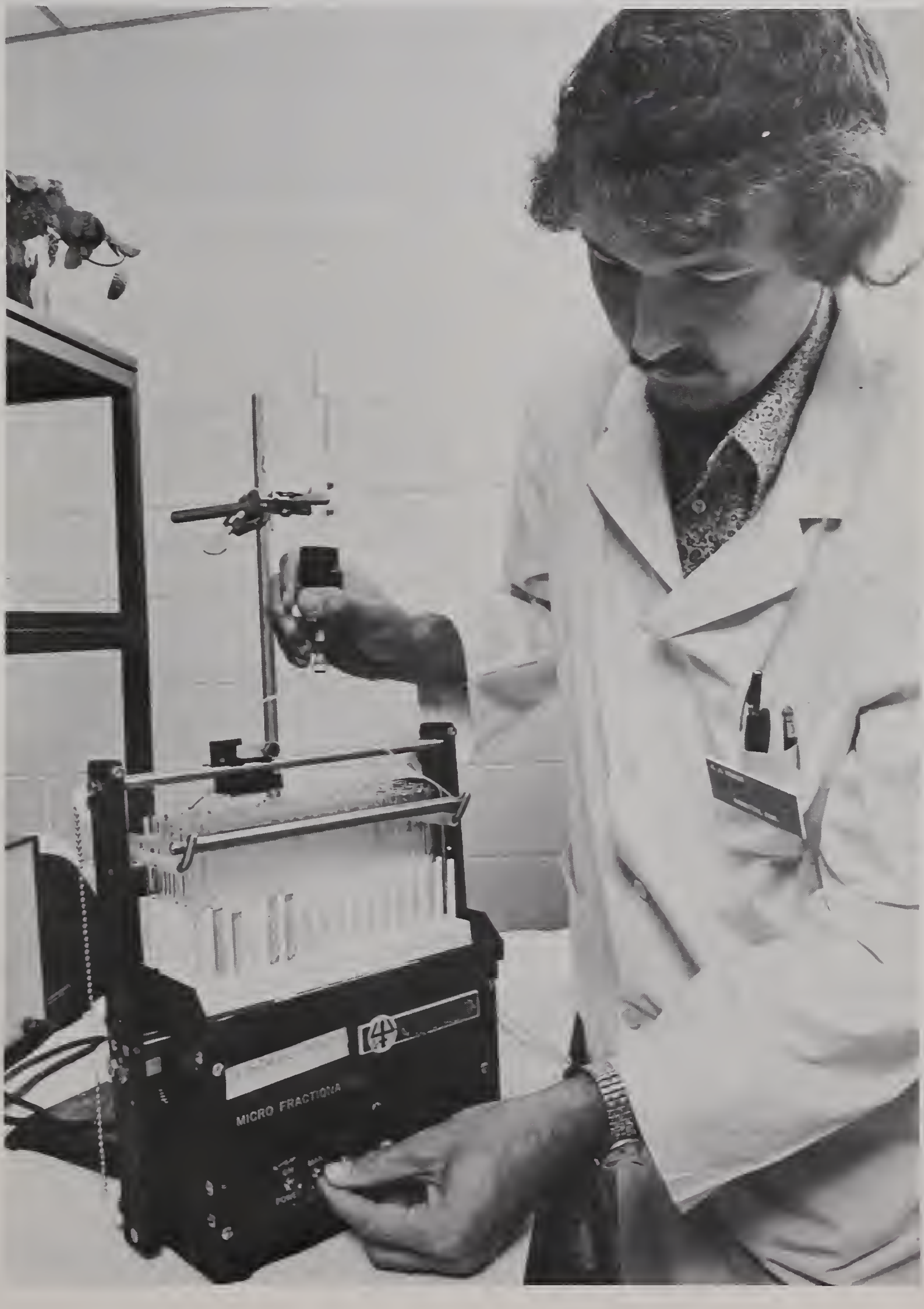
DO INSECTS get diabetes? Probably, if hormonal regulation of their carbohydrate metabolism malfunctions.

This idea suggests that upsetting carbohydrate metabolism to produce a fatal case of diabetes might have promise for biochemical control of insects, says SEA chemist Karl J. Kramer. He heads a team of scientists exploring this possibility at the U.S. Grain Marketing Research Laboratory, Manhattan, Kans.

In higher animals, one form of diabetes is produced when the concentration of the carbohydrate glucose in circulating blood is abnormally high. This condition, known as hyperglycemia, is caused by a deficiency of the hormone insulin.

In insects, the major carbohydrate circulating in the hemolymph, roughly the insect equivalent of blood, is trehalose. And scientists at the University of Chicago and at Manhattan have demonstrated that hormones like those in vertebrates regulate trehalose levels in the hemolymph.

Two peptide hormones with opposite



After the insect insulin is separated by gel permeation chromatography, it is purified by immunoabsorbance. Here, Dr. Kramer collects fractions containing insect insulin from a vertebrate insulin antibody column. These samples are then subjected to bioassay and chemical analysis (0977B1308–31).

functions regulate carbohydrate metabolism in vertebrates and also in insects. Insulin or an insulin-like hormone lowers carbohydrate levels, and glucagon or a glucagon-like hormone raises sugar levels. In addition, glucagon promotes the breakdown of storage carbohydrate in certain organs. A deficiency of glucagon produces hypoglycemia.

Chicago biochemists Howard S. Tager and James Markese, Dr. Kramer, and SEA entomologist Roy D. Speirs first identified a glucagon-like peptide in adult tobacco hornworms by using immunological techniques. Later, they detected glucagon-like and/or insulin-like peptides in the tobacco hornworm, Indian meal moth, cockroach, and honeybee.

Their studies produced the first evidence for a hyperglycemic glucagon-like hormone in insects. A hypoglycemic insulin-like hormone was also demonstrated for the first time.

Both peptides, the scientists found, are stored in the corpus cardiacum and corpus allatum, neuroendocrine glands associated with the brain in insects.

The researchers identified the glucagon-like hormone after injecting extracts of either gland into tobacco hornworm larvae. The equivalent of four corpora cardiaca induced glycogenolysis in an organ known as the fat body reducing the glycogen content to only 9 percent of that in control larvae, Dr. Kramer explains.

Injecting the equivalent of four corpora allata had a similar, but less dramatic, effect on other larvae. The glucagon-like hormone is therefore stored in both glands.

In addition, Dr. Kramer says extracts of both glands showed insulin-like activity in larval hemolymph by decreasing trehalose concentrations by 30 to 40 percent.

The researchers purified insect peptides by gel permeation chromatography and subsequently showed them to be physically and chemically similar to bovine glucagon and insulin. The purified peptides also had the expected hormonal activities.

An oversupply or undersupply of either hormone can kill insects, Dr. Kramer says. Similarity of hormones that regulate carbohydrate metabolism in insects and vertebrates, however, might rule out practical use of chemicals presently known to modulate hormonal levels in higher animals, although several of these do appear to produce diabetic insects in the laboratory.

Hemolymph is bled through the abdominal "horn" of a tobacco hornworm. It will then be freeze-dried into powder and subjected to a purification scheme or immunoassay. Once a purified peptide hormone extract is obtained, scientists can determine its biological function—whether it elevates or depresses the blood sugar (0977B1303–11A).

Hemolymph is drawn from an Indian meal moth as part of a comparative study to see if the effects of insulin peptides are general phenomena (0977B1310–24A).

Instead, he says, a mechanism peculiar to insects for upsetting carbohydrate metabolism is needed. A chemical acting selectively on tissues producing insulin or glucagon in insects but not in higher animals might be developed. Another possibility may be a pathogen that would induce carbohydrate metabolism disorders specifically in insects.

Producing diabetes in insects may one day help to control insect pests.

Dr. Karl J. Kramer is at the U.S. Grain Marketing Research Laboratory, 1515 College Ave., Manhattan, KS 66502.—*W.W.M.*

A Lethal Entrapment

Dr. Davis secures his traps to stakes outside a bee shelter (0178X023-22).

THE scourge of the alfalfa leafcutting bee, the checkered flower beetle whose voracious dietary habits have cost alfalfa seed growers millions of dollars each year, faces lethal entrapment from federal researchers this year.

Leafcutting bees are one of the best and most widely-used alfalfa pollinators. Checkered flower beetles are predators who deposit their eggs in leafcutting bee nests. Beetle larvae are rather large in size and one larva may consume as many as 20 bee larvae.

Last year, alfalfa seed growers in Washington alone lost $6 million because of checkered flower beetle damage to bee larvae. The beetles are also posing serious problems for growers in Idaho, Utah, and Oregon. Pesticides presently used in alfalfa seed production will not kill the beetles, so growers have had to hire persons to stand all day and slap the beetles off bee shelters.

SEA entomologist Harry G. Davis, Yakima, Wash., has developed an attractant-baited trap that captures and kills adult checkered flower beetles without harming the bees.

The trap is a simple device that is easy to maintain. The largest part is a six-quart polyethylene container. In the bottom, on the inside, is an insecticide vapor strip. A large funnel fits over the strip. Around the mouth of the container are holes which are skirted by a collar. Those holes permit beetles to enter the trap, but the collar keeps the bees out. The container is capped and a rubber stopper which is impregnated with a sweet-smelling beetle lure is inserted through the center hole in the cap.

Remarkable in its simplicity, the only parts of the checkered flower beetle traps not shown here are the insecticide strip that goes at the bottom and the beetle lure that fits in the cap (0178X023-6).

The trap is enclosed in a wire bale and secured to a stake positioned outside the bee shelter. Beetles (both male and female) enter the trap through the openings under the collar, slide down the funnel, and are killed by the insecticide strip.

In fields where Davis tested his traps this past summer, more than 250,000 beetles were captured. At one shelter he collected a total of 30,000 beetles, including 18,000 females capable of producing enough larvae to consume 9 million bees. Davis expects 2 to 4 traps to be sufficient to control the beetles at a typical leafcutting bee shelter and, he says, the attractant may have to be replaced only once or twice during the critical 3-month (June-August) bee nesting season.

A pest management firm plans to manufacture Davis' traps commercially next year. The traps will be used to determine checkered flower beetle populations in several alfalfa seed-producing areas.

Dr. Harry G. Davis is with the Insecticide Analysis and Insect Attractant Research group, 3706 Nob Hill Blvd., Yakima, WA 98902.—*L.C.Y.*

New Mechanical Rhubarb Harvester

FIELD grown U.S. rhubarb has declined 11 percent since 1974, due largely to the high cost of hand harvesting. In the spring of 1976, after surveying growers and processors throughout the nation, Dale E. Marshall decided the harvesting problem could be solved.

He designed, constructed, and tested an experimental rhubarb harvester, all within 120 days, on the Michigan State University campus at East Lansing, where he is an agricultural engineer with USDA's Science and Education Administration (SEA).

Because of variations of size and spacing of plants, and the small number of acreages large enough for field testing, Mr. Marshall tested the machine in 1976 on four Michigan farms and on one in New York.

One of the cooperating growers, Hugh Bowling, Bear Lake, Mich., ordered a commercial unit from a manufacturer at Bailey, Mich., based on the research machine. It was completed and used to harvest 50 tons of rhubarb late in the 1976 season. Bowling's machine was modified and used to harvest 250 tons in 1977.

Mr. Bowling found that hand harvesting costs range from 60 to 120 percent of the price growers receive for rhubarb. He estimated his costs at 1.6 cents per pound by machine in 1977, compared with 3.3 cents per pound by hand the year before.

Another commercial unit was built for Clarence French, Brampton, Ontario, who machine-harvested 190 tons of rhubarb in 1977. He said the mechanical harvester was more effective on varieties having small stalks than on those having large stalks. The machine was about equal to hand labor, about 7 man-hours per ton on large stalked varieties, but much more efficient (about 4.5 man-hours per ton) on the small stalked varieties.

Above: In the mechanical rhubarb harvester developed by SEA Agricultural Engineer Dale Marshall, two rotating disks cut the stalks about 1 inch above the ground. The technique is based on the design of an obsolete cucumber harvester (0877A1163–21A).

The small farmer who wants to grow rhubarb for commercial production is way ahead with a new mechanical harvester recently developed by an SEA engineer in East Lansing. The new machine is a possible solution to the labor problem for small growers, as the harvester may save up to four times the number of worker-hours required. The prototype, with the aid of 8 to 10 workers, can harvest two tons of the small-stalked variety per hour.

Mr. French said his machine could harvest about 2 tons of the small-stalked variety in 9 man-hours. By hand, it took 36 man-hours to harvest that amount. As a result, he plans to increase his rhubarb next year by 10 acres.

Mr. Marshall's studies show that the harvester requires 8 to 10 people: A tractor driver, 4 to 5 sorters on the harvester, two tractor drivers for the catch wagons and another sorter on the wagon. One person is needed for fork-

Mr. Marshall inspects some of the rhubarb that was not removed by machine harvesting. So far, the efficiency (recovery rate) of the harvester is 65 percent—but that could improve to 85 percent with improvements in machine design and rhubarb culture (0877A1162–28A).

lift loading and unloading of pallets from the truck.

Harvesting studies show about 65 percent of the rhubarb is recovered by the machine method. He feels this can be increased to 75 to 85 percent with improvements in machine design and rhubarb culture.

A self-propelled rhubarb harvester, also based on the SEA design, was built in Harrisburg, Oregon for grower Roger Detering. Early tests were successful enough that Mr. Detering increased his acreage by 10 acres in 1977.

The Michigan Frozen Food Packers Association provided some funds for construction of the original machine and growers provided the fields for testing.

Mr. Marshall found that two different attempts at a mechanical rhubarb harvester were made by growers several years ago. Both machines used a sickle bar system to cut the rhubarb.

In contrast, Mr. Marshall started with an obsolete cucumber harvester that used two 36-inch rotating disks which cut the stalks about 1 inch above the ground. The stalks are gathered and elevated by spring-loaded belts and are then transferred to two moving belts which orient the stalks vertically in the unit, hanging them by their leaves. Each stalk is cut again just below the leaf and dropped into a bulk box. The leaves are carried to the back of the machine and deposited on the ground.

Labor availability is a major factor in rhubarb production, Mr. Marshall says, and is also the major reason rhubarb is usually grown on small acreages. The new harvester should provide a solution to the labor problem for small growers and reverse the trend of declining acreage by permitting more efficient production.

Mr. Dale E. Marshall is with the Fruit and Vegetable Harvesting Research group, Dept. of Agricultural Engineering, Michigan State University, East Lansing, MI 48823.—*R.G.P.*

Test-tube Bulls

A COLLECTION of Montana sire bulls have achieved an immortality of sorts, for their stored semen has proven to be an excellent, cost-saving tool for determining the success of a cattle-breeding program.

In Miles City, Mont., SEA researchers recognized that selective breeding effects could be determined by storing semen from sires for a number of years and then comparing their progeny (bred by artificial insemination) with the progeny of contemporary sires.

Measuring production trends in a herd of cattle after years of selective breeding is a difficult task because management techniques generally improve, and increased cattle productivity may or may not be the result of the breeding program.

The standard method of measuring a breeding program's success has been to maintain a control herd—a population of cattle that is not selectively bred. This method is very expensive because it may tie up 50 percent of a program's cattle and facilities throughout the duration of the program.

Using stored semen to assess a breeding program's success is not only considerably less expensive than maintaining a control herd, it is also more accurate in its assessments. Control herds often undergo a "genetic drift," thereby making it difficult or impossible to accurately compare the products of the breeding program with the original cattle, or cattle very similar to them. Of course, there is no genetic drift with stored semen.

At the start of a breeding program, semen is collected from a group of sires, then stored indefinitely by freezing. To later test the program's progress, semen from the first generation of bulls is thawed and used on a group of randomly assorted, unrelated cows. These cows are as equal as possible in production potential to a group of cows which are mated to the latest generation of bulls. Steer progeny of both generations are then compared through feedlot and carcass evaluations. Cow progeny are compared for growth and maternal performance after producing calves.

The stored semen technique was first used at the Miles City station to evaluate the progress of two inbred lines of Herefords. Semen was collected from several sires of both Lines 1 and 10 in 1955 and 1956. After two generations had elapsed the semen from these bulls was tested against semen from bulls born in the 1960's. In both lines, all weights of progeny born to the younger generation bulls surpassed the weights of progeny born to the older generation bulls, indicating that improvements in the lines had been accomplished.

SEA animal scientists Joseph J. Urick and Ray R. Woodward plan to compare two bulls born in 1953 and one born in 1955 with several current Line 1 herd sires at the station. This comparison represents approximately a five-generation interval between sires—an impossibility without the use of stored semen!

Dairy cattle breeding programs or any other breeding programs where a sire animal's semen can be frozen could use the stored semen technique to evaluate the program's success.

Dr. Ray R. Woodward and Mr. Joseph J. Urick are with the U.S. Range Livestock Experiment Station, Route 1, Box 3, Miles City, MT 59301.—*L.C.Y.*

SPAR . . . A New Research Capability

Biological laboratory assistant Mary Fields marks and dates the growth progress of roots from wheat plants. A photographic record of these growth patterns is made after the roots are traced and marked. (0378X328–20).

SEA and Clemson University scientists have designed, constructed, and tested a microcomputer-controlled and monitored system for studying whole-plant responses and gathering complete data for developing dynamic crop simulation models.

The Soil-Plant-Atmosphere Research (SPAR) System will allow scientists for the first time to determine whole plant (root and top) responses to microclimatic and soil environment changes. Among other uses, the SPAR system enables scientists to study air pollution effects on plants and to perform integrated pest management experiments.

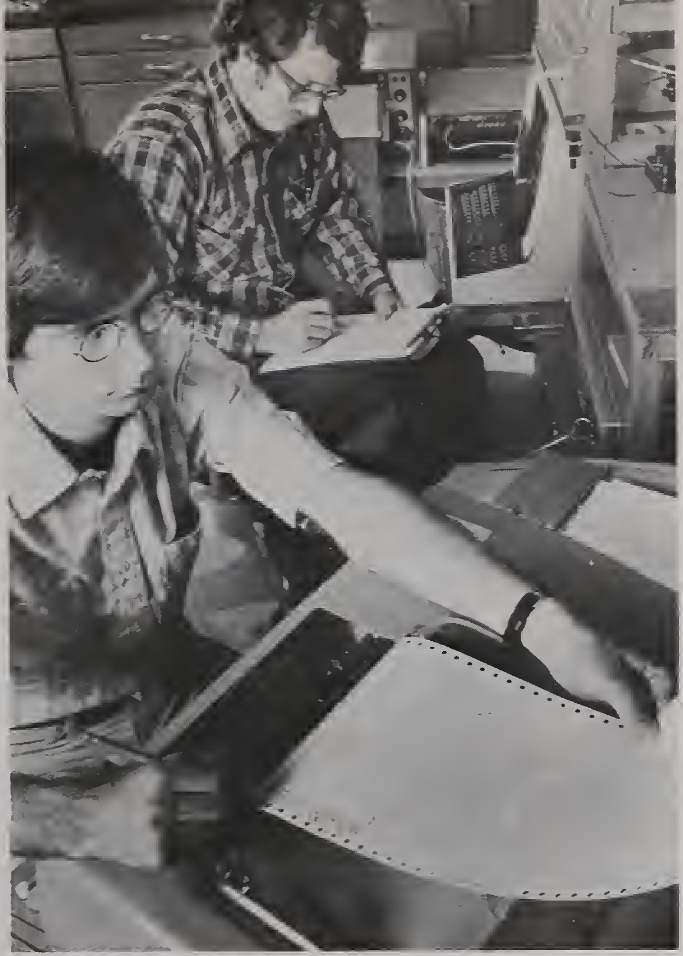
The use of the SPAR system to provide the necessary data for crop simulators could have far-reaching impact in the areas of crop-yield prediction, crop management, and improvement of photosynthetic and yield efficiency. Rates of certain physiological processes (e.g. photosynthesis and growth as well as environmental inputs) are controlled independently in these SPAR units. The combination of these facilities with the computer simulation model of crop growth provides a new and powerful approach in the analysis of agronomic systems.

Each SPAR unit consists of a steel soil bin 2 m long, 0.5 m wide, and 1 m deep. The soil bin is topped by a plastic aerial chamber 1.5 m high. The soil bin is separated from the aerial chamber by a plastic sheet hermetically sealed around each plant to prevent gas exchange between soil and aerial chambers.

The units were designed to contain two or more rows of plants, 0.5 m long, perpendicular to its long dimension and oriented in a north-south direction.

Each unit is provided with a pressure-regulated water outlet, a flow meter, and a remotely controlled, electrical solenoid valve for automatic irrigation control.

Temperature of the soil bin is thermostatically controlled by brine, which is heated or cooled by a heat pump. The brine flows through copper tubing placed around the bin.



Left: Air temperature, soil moisture, soil temperature, humidity, solar radiation, carbon dioxide level, and transpiration rate in each SPAR unit is recorded every 15 minutes—along with the status of the sensing instruments. James Dunlap (foreground), an electrical engineer with Clemson University, verifies teletype printout generated by the SPAR units while SEA mathematician John Parsons checks instantaneous control parameters for "up-to-the-second" data (0378X329-9).

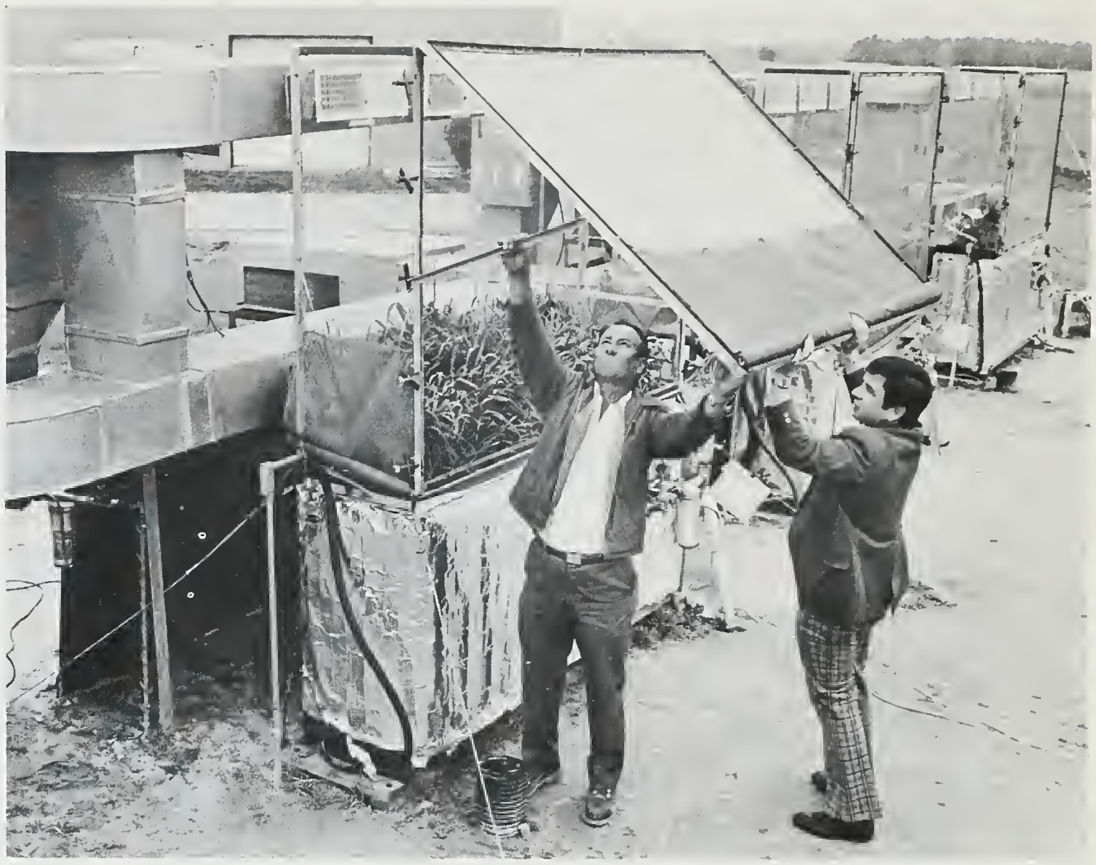
Below: Dr. Phene and Mr. Dunlap read flow rates of carbon dioxide being delivered to the aerial or top (plant growth) portions of the three SPAR units (0378X330-23A).

Access to the soil can be gained either by removing an exterior steel-reinforced glass panel or by means of nine access ports which are located on the opposite side of the soil bin and provide quick access at various soil depths. These ports can also be used to install sensors. Visual observation of the soil and root system can be made through the reinforced glass panel.

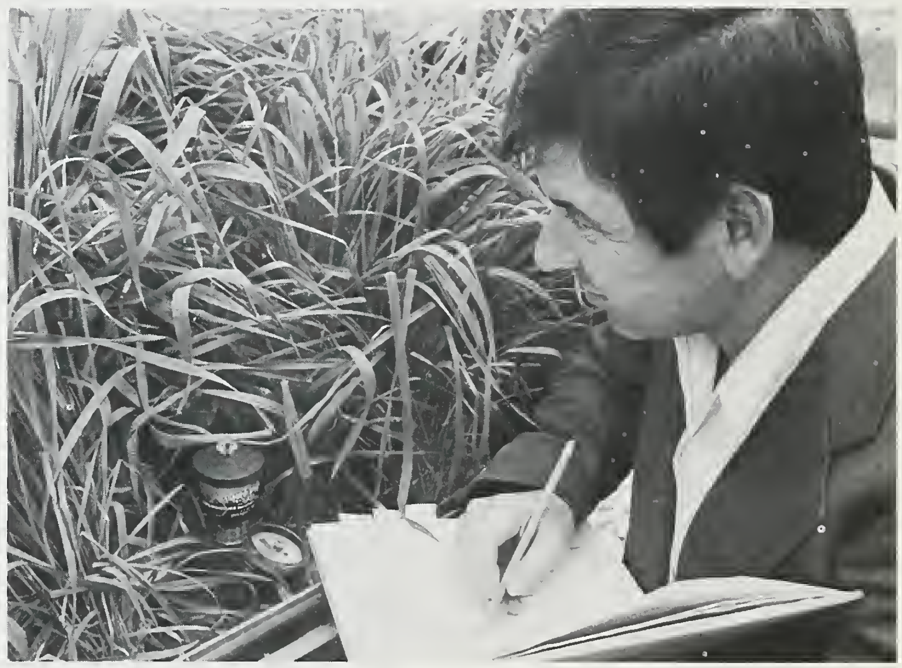
In the base of the soil bin is a series of porous ceramic rods attached to a manifold that can be used for drainage or water table control by subirrigation.

Temperature of the aerial chamber is regulated with an air conditioner and an electric heater under microcomputer control.

Access to the chamber is gained through a side panel which is hinged at the top. The door is sealed with a



*Ready access to the inside of each SPAR unit enables a variety of direct measurements to be made on a frequent basis. Hydrological technician Jimmie Vaught (left) and Dr. Phene raise the glass side panel of SPAR unit #1 (**right:** 0378X324–8A), after which Dr. Phene logs readings from five tensiometers that gauge soil moisture potential (**below right:** 0378X324–14A). In SPAR, seemingly "minor" considerations are often brought into play. **Below:** SEA mathematician John Parsons adjusts the height of a plastic screen to simulate in-row shading (0378X325–13).*



rubber gasket to make it airtight.

To simulate field conditions, each side panel on the aerial chamber is fitted with an adjustable plastic screen which is raised daily to the height of the plants to simulate within-row shading as the crop grows.

With an array of sensors and instrumentation, soil matric potential and micrometeorological variables such as solar radiation, net radiation, ambient leaf and soil temperatures, CO_2 assimilation, and relative humidy are both measured and controlled.

Scientists can use the SPAR units to establish crop management principles and use these results in models to obtain better estimates of crop yields and market stabilization.

The units are located at the Coastal Plains Soil and Water Conservation Research Center, Florence, SC. Conducting the research were Claude J. Phene, soil scientist; Donald N. Baker, agronomist; John E. Parsons, mathematician; and James M. McKinion, electrical engineer, all of SEA, and Jerry R. Lambert, agricultural engineer, and James L. Dunlap, electrical engineer from Clemson University.

Dr. Donald Baker and Dr. James McKinion are at Mississippi State University, P.O. Box 5465, Mississippi State, MS 37962. Mr. John Parsons and Dr. Claude Phene are at the Coastal Plains Soil and Water Conservation Research Center, Darlington Highway, P.O. Box 3039, Florence, SC 29502.—*V.R.B.*

Transmissible gastroenteritis, a specific enteric viral disease of young pigs, is characterized by vomiting, diarrhea, dehydration and death within a few days of infection. Dr. Kemeny performs a necropsy on a baby pig that had been innoculated with a slaughterhouse isolate of the virus. Laboratory technician Leon Wiltsey records Dr. Kemeny's findings. (0378X205-6).

Above: Cell cultures identified as TGM viruses were fed to suckling pigs kept individually in isolation cages. The baby pig being held by laboratory technician Leon Wiltsey is about to receive a dose of the virus from Dr. Kemeny (0378X 207-36).

Sows Can Carry TGE

EVIDENCE that sows are potential carriers of the transmissible gastroenteritis (TGE) virus suggests a way the virus is perpetuated on farms between disease outbreaks.

SEA veterinary medical officer Lorant J. Kemeny detected TGE virus in the oral cavity of 61 apparently healthy sows among 2,058 slaughtered at a central Iowa packing plant between March and June 1977. This is the first time the virus has been isolated from the oral cavity of apparently healthy sows.

Sows persistently infected with TGE virus may infect their own pigs or other litters, he says, particularly when housed with susceptible gilts during winter months.

An earlier study by Dr. Kemeny at the National Animal Disease Center in Ames, Iowa, suggested that sows may have an important role in spreading TGE virus in the farrowing house (AGR. RES., Oct. 1975, p. 10). Susceptible sows in direct contact with sick pigs in that study readily developed upper respiratory infection. The latest study indicates sows may also have a role in maintaining TGE virus between outbreaks.

Dr. Kemeny collected fluids by rubbing a cotton swab over the surfaces of the tonsils and epiglottis of sows after slaughter. He then inoculated cell cultures with the fluids and observed the cultures for development of the specific cytopathic effect of TGE. Sixty-one isolates were identified as TGE virus.

He then administered the 61 isolates orally to 2- to 3-day-old pigs that had been born from TGE-negative sows. All these young pigs showed clinical signs of TGE within 1 to 2 days of inoculation with the virus, and 17 died. The remaining 44 pigs had specific antibody to TGE virus 15 days after inoculation.

Isolation of TGE virus from the oral cavity of suspected hogs may be a useful procedure for identifying and eliminating asymptomatic carriers in latently infected herds.

Dr. Lorant J. Kemeny is at the National Animal Disease Center, P.O. Box 70, Ames, IA 50010.—*W.W.M.*

An ornithosis bacterin (an inactivated bacterial product used for immunization purposes) is administered to turkeys by intratracheal inoculation (actual angle of inoculation is different than demonstrated here). The effect of the bacterin is to immunize the turkeys against lethal chlamydial infection (0378X210–6).

Chlamydial Immunity Mechanism Identified

VACCINES whose purpose is stimulating production of specific antibodies to the invading disease agent have been only moderately successful in protecting birds and mammals against chlamydiosis, a bacterium-caused respiratory disease. Now we know why.

SEA microbiologist Leslie A. Page and others had evidence that antibody stimulation is not the dominant mechanism of chlamydial immunity. His earlier studies (AGR. RES., Nov. 1975, p. 12) suggested cell-mediated immunity as the chief mechanism. This form of immune response causes sensitization of white blood cells, or leucocytes.

Dr. Page therefore initiated studies oriented toward stimulating cell-mediated immunity in turkeys, in which chlamydial disease is known as ornithosis. His investigations at the National Animal Disease Center, Ames, Iowa, produced these significant results:

—An immunization procedure that gives 100 percent protection against death from ornithosis and 90 percent protection against development of lesions that would cause condemnation of organs or carcasses at a USDA-inspected poultry processing plant.

—A diagnostic test that predicts the ability of birds to resist ornithosis infections.

—And convincing evidence that the cell-mediated immune mechanism indeed has the dominant role in resistance to ornithosis.

The immunization procedure effective for turkeys should also protect ducks, pigeons, and parrots, Dr. Page says, and his findings should be applicable in studies of chlamydial pneumonia in lambs, calves, horses, goats, cats, and dogs. Chlamydiosis is caused by the bacterium *Chlamydia psittaci*.

In turkeys, prompt antibiotic treatment can restrict losses if ornithosis is diagnosed early. Routine use of effective vaccines may have a place in high-risk flocks, such as those in epidemic areas.

Dr. Page found that turkeys can be immunized against severe challenge infection with a lethal strain of *C. psittaci* if given two doses of a potent bacterin, if the interval between doses is 8 weeks,

and if inoculation is via the trachea. Less effective protection resulted from two doses 2, 4, or 6 weeks apart, from only one inoculation, or from two intramuscular inoculations.

The immunization procedure giving the most effective protection was clearly related to stimulation of cell-mediated mechanisms, Dr. Page found. Chlamydia-specific sensitization of white blood cells was evident only after the second bacterin inoculation, and only if bacterins were administered at least 8 weeks apart.

A lymphocyte mitogenesis test using white blood cells from freshly drawn blood of vaccinated turkeys indicates stimulation of cell-mediated immunity. White blood cells undergo nuclear DNA synthesis when cultured in the presence of purified suspensions of chlamydiae. Synthesis of new DNA is detected by adding radioactive thymidine to the white cell culture and assaying the culture later for radioactive DNA.

Dr. Page's studies produced additional evidence that cell-mediated immune mechanisms play a dominant role in resistance to ornithosis.

The immunization procedure inducing high levels of immunity to challenge infection produced only low levels of antibodies detectable by the complement fixation test—and none by the agar gel precipitin test. Effective protection is therefore not dependent upon a high level of antibodies.

Finally, Dr. Page showed that surgical removal of the bursa from newly-hatched poults did not impair development of bacterin-induced immunity when they were vaccinated at 10 weeks of age and later challenge-exposed. The bursa is required for antibody synthesis in birds. But surgical removal of the thymus—essential in the cell-mediated immune mechanism—prevented development of immunity in 83 percent of a second group of turkeys similarly vaccinated and exposed.

Dr. Leslie A. Page is at the National Animal Disease Center, P.O. Box 70, Ames, IA. 50010.—*W.W.M.*

Reduce Leaching with Irrigation, Fertilization

FERTILIZED land that received small but frequent supplemental irrigations lost 26 fewer pounds per acre of nitrate-nitrogen from leaching than did fertilized land that received less frequent but larger irrigations. Yet corn yields were just as high.

Science and Education Administration scientists at Morris, Minn., made these observations in a study involving droughty sandy soil in west central Minnesota. Sufficient fertilizer had been applied to produce corn yields of 150 bushels per acre.

Donald R. Timmons, soil scientist, said he and his colleagues at Morris have an interest in efficient use of water and fertilizer. The research team also conducted the study with concern about a potential environmental hazard that might develop if nitrogen in nitrate form accumulates in groundwater that underlies irrigated areas.

A severe rainstorm sometimes occurs after an irrigation in areas where the sandy loam has a low water holding capacity. Water in excess of the soil water capacity then percolates through the soil profile carrying dissolved nutrients away from the plant root zone.

In the 3-year study, researchers irrigated corn whenever the upper 3 feet of soil was depleted to half of its water holding capacity. Some plots received 1 inch of water at a time and other plots received less frequent 2-inch applications. On some plots, nitrogen and other plant nutrients in granular form were broadcast and disked in at planting. On other plots, the nitrogen was applied as liquid through the irrigation system four times during the growing season.

The researchers found that plots fertilized with granular nitrogen and irrigated at the 2-inch rate lost about 45 more pounds of nitrate-nitrogen per acre than did the non-irrigated and fertilized corn. In contrast, plots with the frequent 1-inch irrigations lost about 10 more pounds of nitrate nitrogen per acre than the non-irrigated and fertilized corn.

Other plots irrigated at the 1-inch rate but fertilized with periodic applications of liquid nitrogen lost about 9 more pounds of nitrogen as nitrates that did the nonirrigated and fertilized corn.

The scientists found that average percolation rates from corn plots irrigated at 1- and 2-inch rates were 56 and 267 percent greater, respectively, than from nonirrigated corn. But the average concentration of nitrate per unit of water that percolated below the root zone was greatest from the nonirrigated fertilized corn.

Participating with Mr. Timmons in the study were Mr. Anthony S. Dylla and Mr. Hollis Shull, agricultural engineers. The three researchers are with the North Central Soil Conservation Research Laboratory, Morris, MN 56267.—*G.B.H.*

Pea Flour Boosts Protein

SUBSTITUTING flour made from ground peas for 15 percent of the wheat flour in a loaf of bread boosts the total protein value of the loaf by 15 percent without affecting taste, baking quality, or the cost of producing the bread.

SEA researchers at the Wheat Breeding and Production Research Laboratory have found that breads fortified with pea flour, in addition to being high in protein value, are also high in fiber and carbohydrates and are low in fats. The high fiber content can mean reduced constipation for those so afflicted.

Americans eat 50 million pounds of bread daily. The wheat that goes into this bread provides more nourishment for Americans than any other food source. But though wheat is high in protein it suffers from an imbalance of the amino acids that make up that protein.

Specifically, wheat is low in lysine, the essential amino acid that determines the human body's ability to utilize protein. Consequently, nutrition researchers are trying to fortify wheat flour with a low-cost material that is high in lysine. Soy flour has been the most often-used additive. It is nutritionally good but its strong taste is found unpleasant by many.

Peas are high in lysine and complement wheat when the two are combined in flour form. Though dried peas are widely used throughout the world as a protein source in low-cost diets, in this country pea flour has been used primarily as a thickening material for soups.

SEA food technologists Herbert C. Jeffers, Gordon L. Rubenthaler and Patrick L. Finney, and SEA technician Pat Anderson, along with Bernard L. Brunisma of Washington State University, all believe pea flour would be the ideal wheat flour fortifier.

The scientists investigated the physical dough properties and baking potential of yellow peas in the belief that the yellow color would have less effect on the final color of the bread dough than would green peas. However, it was learned that most of the pea flour color is bleached out during baking and so green peas could also be used with little color change to the wheat flour dough.

Besides benefiting the bread-eating public, a greater use of pea flour could also benefit wheat farmers of the Pacific Northwest where 90 percent of all U.S. peas are produced. The Northwest suffers severe erosion problems in wheat fields and growing wheat onto pea stubble offers excellent erosion control. Until now, a wheat-pea crop rotation system in this area has been limited by the small U.S. market for peas. Currently, most of our harvested peas are exported.

This research was conducted at the Wheat Breeding and Production Research Laboratory, Johnson Hall, Washington State University, Pullman, WA 99163.—*L.C.Y.*

AGRISEARCH NOTES

Contour Furrowing Helps Forage

CONTOUR FURROWING increased forage production by a whopping 123 percent on arid, southeastern Montana rangeland sites during 6 years of SEA tests.

Forage production is notoriously poor in southeastern Montana because scant precipitation and low soil infiltration rates limit the water stored in the soil. Though contour furrowing is known to increase rangeland soil water, until now its effects on forage production have been unknown.

To learn these effects, SEA hydraulic engineer Earl L. Neff and SEA range scientist J. Ross Wight with the Northern Plains Soil and Water Research Center established 16 watersheds on saline upland and panspot range sites. The saline sites are ordinary uplands where salt and/or alkaline accumulations are apparent. Panspots are areas where hard clays or similar materials lie close to or at the soil's surface in shallow depressions.

Half of the watersheds at each site were left in their natural condition and half were furrowed. Over the 6-year study period, contour furrowing increased forage production by 86 percent on the saline uplands and by 159 percent on the panspot sites.

The SEA researchers found that the increased forage production was a direct result of increased soil water content. Overwinter soil water recharge was increased 157 percent on the contour-furrowed saline upland sites and 162 percent on the furrowed panspot sites. Higher infiltration on the panspot sites accounted for the differences between the two types of sites.

Contour furrowing increased the soil water by creating additional surface storage, reducing spring and fall runoff, and providing a longer time for precipitation to infiltrate into the soil. Also, furrows increased the amount of snow water trapped and stored for later plant use by 60 percent.

Mr. Earl L. Neff and Dr. J. Ross Wight are with the Northern Plains Soil and Water Research Center, P.O. Box 1109, Sidney, MT 59270.—*L.C.Y.*

Gypsum Aids Sorghum Quality

ADDING GYPSUM to alkaline soils makes more iron available for sorghum and increases yields by 17 percent. Quality of grain is also increased, reports soil scientist Sterling R. Olsen, Ft. Collins, Colo.

Sorghum grown on alkaline, calcareous soils, typically found in semiarid regions, often suffers from iron chlorosis, a plant deficiency of that mineral. On some of these soils, well supplied with molybdenum, sorghum absorbs even less iron, causing even greater decreases in yields and quality.

Greenhouse studies show that on four of six soils from different semiarid regions in the country, adding gypsum at the rate of 275 pounds per acre reduces plant uptake of molybdenum. This results in increased iron uptake and increased yield and quality of sorghum.

These four soils are: Anselmo fine sandy loam, Otero fine sandy loam, Platner sandy loam, and Stoneham loam.

Olsen attributes the resulting increased sorghum quality to greater concentrations of iron, magnesium, manganese, and zinc in the plant, thus making it a more valuable feed.

A symptom of iron chlorosis in sorghum is yellow or pale green leaves with darker green near the veins.

Dr. Sterling R. Olsen is with the Soil Phosphorus Laboratory, Plant Science Bldg., Colorado State University, Ft. Collins, CO 80523.—*D.H.S.*

Hanging on 'till Harvest

SEA SCIENTISTS have developed a new instrument that can detect and measure small differences in the degree of "stormproofness" in cotton bolls.

Stormproof cotton was developed for the rolling and high plains of Texas, Oklahoma and New Mexico where cotton bolls must resist violent weather to remain on the plants until 90 to 95 percent of the crop is open for once-over stripper harvesting.

Agricultural research technician Ray E. Dilbeck designed the new "Lock Tenacity Instrument" which can quantify small degrees of the stormproof trait in cotton.

Working with plant geneticist Jerry E. Quisenberry, Mr. Dilbeck designed the instrument to help plant breeders develop cotton varieties more able to withstand until maturity the high winds, rain, ice, and snowstorms that characterize the fall weather where this cotton is grown.

Mr. Ray E. Dilbeck and Dr. Jerry E. Quisenberry are with the TAMU Agricultural Research and Extension Center, Route 3, Lubbock, TX 79401.—*B.D.C.*

More Straw With Semi-dwarf

SEMIDWARF hard red spring wheat varieties averaged 600 more pounds of straw per acre than did full size wheat varieties at 40-bushel per acre grain yields in North Dakota tests.

Dr. Armand Bauer says the results suggest that vegetative characteristics, other than height, contribute to straw yield differences.

Dr. Bauer, a soil scientist with USDA's Science and Education Administration in Mandan, N. Dak., worked with Dr. Joseph C. Zubriski, North Dakota State University soil scientist on the project.

Their objective was to determine if there is a relationship between straw and grain production that could be used to predict straw yields based on the grain yields. Results indicate a 40-bushel per acre yield of grain of a standard height variety will produce between 1.3 and 2.0 tons of straw. The same grain yield from a semidwarf variety will average about 20 percent more straw per acre than the standard varieties.

"Straw production can be estimated within about 500 pounds per acre on the basis of the grain yields when yields are normal or above normal. When grain yields are lower than average, the straw estimates are less predictable," Dr. Bauer said.

Varieties tested included Waldron, Ellar, and the semidwarf varieties Olaf and Lark.

Dr. Armand Bauer is with the Northern Great Plains Research Laboratory, P.O. Box 459, Mandan, ND 58554.—*R.G.P.*

UNITED STATES GOVERNMENT PRINTING OFFICE
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AGRISEARCH NOTES

Help for Tobacco, Peanuts

BIOLOGICAL CONTROL of brown spot and Cetcospora leaf spot may one day aid tobacco and peanut growers. Bacteria antagonistic to these fungus-induced foliar diseases have been successfully tested in laboratory and fiield experiments.

Researchers mixed bacterial antagonists with pathogen spores and inoculated plants in controlled greenhouse tests. The laboratory experiments indicated that biological control was possible. Bacterial antagonists sprayed in field tests on tobacco plants two days prior to artificial inoculation resulted in 33 percent less brown spot. Control of this disease is vital to growers of flue cured and burley tobacco. Nine weekly spray applications to field-grown peanut plants resulted in 38 percent less leaf spot, as compared with plants that had not been sprayed.

These results indicate biological control of foliar diseases is possible in the field. However, control in the field is dependent upon an environment favorable to the bacteria. Failure of the bacteria to survive in the field jeopardizes biological control. Further research on disease control mechanisms and the development of methods for bacterial survival after spray application will lead to biological control for these leaf diseases, according to Dr. Harvey W. Spurr, Jr., of the Tobacco Research Laboratory, Route 2, Box 16G, Oxford, NC 27565.—*E.L.*

Resistance to Sunflower Beetle

WILD SUNFLOWERS may give their commercial cousins resistance to the sunflower beetle, according to SEA entomologists Charlie E. Rogers and geneticist Tommy E. Thompson who grew and screened several species of wild sunflowers for resistance to the pest.

All of the wild sunflowers screened showed some resistance, and three (blueweed, willowleaf sunflower, and Jerusalem artichoke) killed 100 percent of the immature stages (larva and pupa) of sunflower beetles that fed on the plants.

"Wild sunflowers have the resistance we need," says Dr. Rogers, "and this resistance can be easily transferred into commercial lines by crossing."

Dr. Thompson explained that the resistance in wild sunflowers could take the form of "antibiosis;" that is, it could involve a toxic substance that kills the beetle, or the resistance could involve "non-preference," a lack of a substance that prompts the beetle to feed. Resistant sunflower varieties could be developed by exploiting either trait.

The sunflower beetle is found in most of the United States and in southern Canada. The insect can reduce sunflower yield by up to 30 percent by feeding on the leaves of young plants.

No insecticides have been approved for use against the beetle, so a transfer of resistance from wild sunflowers would be very beneficial to domestic sunflowers, an increasingly important oilseed crop.

Charlie E. Rogers and Tommy E. Thompson are located at the Southwestern Great Plains Research Center, Bushland, TX 79012.—*B.D.C.*

When reporting research involving pesticides, this magazine does not imply that pesticide uses discussed have been registered. Registration is necessary before recommendation. Pesticides can be injurious to humans, domestic animals, desirable plants, and fish or other wildlife—if not handled or applied properly. Use all pesticides selectively and carefully.

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